ASSESSMENT OF YOUNG SWIMMERS' TECHNIQUE WITH TEC PA TOOL

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Abstract Aim of the current study was to examine the reliability and validity of a new tool, developed for the assessment of young swimmers' technique in all swimming strokes. The sample of the study was 119 swimmers (63 boys and 56 girls), aged 8 to 12 years old. To evaluate swimmers' technique, each of them performed 15m for each one of the swimming strokes in individual medley order. A digital camera, placed 5m above the pool's surface, recorded the swimming bouts. Three experienced swimming coaches evaluated the recorded videos with the new technique's evaluation tool named Tec Pa. Tec Pa assess six important key points of swimming technique in each stroke. According to the results no statistical significant differences were showed between the scores of the swimmers' evaluation by the three coaches ($p > 0.05$). Moreover, the association between the scores was statistically significant high ($\tau = 0.863$; $p < 0.05$). The findings of the current study reveal that Tec Pa is valid and reliable for the young swimmers' technique evaluation, with high strength of association. Also, Tec Pa can be used by the coaches to enhance the free observation method, which is mainly used, in young swimmers.

Key words Butterfly, backstroke, breaststroke, freestyle

Introduction

Technique is one of the most important parameters in sports (Lätt et al., 2010). In sports such as gymnastics and artistic swimming evaluates the technique for the ranking of the athletes and the determination of the winners. Although competitive swimming does not belong to this kind of sports, the swimming technique determines performance to a great extent and consequently the competition winners, especially in young swimmers. Thus, the

assessment of the swimming technique could be a useful tool to improve the swimming training programs and the overall swimming performance.

Technique's evaluation occurs in three observation stages. The first is the free observation which is not structured and which can be applied instantly in the swimming pools. This is subjective, economical, and fast. The second is the direct observation which is structured and which can be applied in the field too. It has a higher degree of objectivity than free observation, and is still economical and fast. The third method is the scientific observation which is a structured analysis used in experimental situations, and even though it is objective, it is time-consuming and costly (Pion, Devos, Dafour, 1988).

Technique's evaluation is a very difficult task (Costill, Lee, D'Acquisto, 1987). Less (2002) reviewed that there are three evaluation technique approaches: a qualitative, a quantitative, and a predictive approach. The qualitative method is used mostly in free observation and less in the direct method. It is characterized by observation and subjective judgments which are based on biomechanical principles. However, due to their subjective nature, this approach is characterized by a low impact.

Mooney et al. (2015) showed that the qualitative swimming technique characteristics are difficult to observe and need more study and analysis. Qualitative analysis has been described as the method which includes movement analysis, clinical diagnosis, skill analysis, error detection, observation, eyeballing, observational assessment, and systematic observation. Qualitative method is not unorganized, vague, or arbitrary in nature (Knudson, Morrison, 1997).

In swimming, the qualitative assessment method is the most frequent way to evaluate swimmers' technique. Often, in this method of analyzation, the coaches place a video camera underwater or outside the pool, in a spot where swimmers can be easily observed. Then, the coaches assess the swimmers' technique through the combination of qualitative and quantitative data that are known from their experience and the scientific studies (Arellano, Lopez-Contreras, Sanchez-Molina, 2002; Marouco, Sacadura, Amaro, Matos, 2010; Madureira, Bastos, Corrêa, Rogel, Freudenheim, 2012).

On the other hand, quantitative method is used mostly in scientific observation and less in direct. It involves the data collection of selected technical parameters (Less, 2002). These parameters can be defined through camera observation. In quantitative analysis the values of some variables at important instants in the swimming may also be identified. Often, these values called performance variables and contribute to a valid assessment of the sports movements (Bartlett, 2007).

In quantitative method, efficiency parameters such as swimmers' velocity, stroke rate, stroke length, etc are assessed. The parameters' evaluation occurs through devices that provide detailed information about the strengths and weaknesses of the swimmers' technique (Staniak, Buśko, Górski, Pastuszak, 2016). Currently, more sophisticated approaches have been used such as the Particle Image Velocimetry (P.I.V.) method, which is a flow visualization technique and the Computational Fluid Dynamics (C.F.D.) method, which is a numerical analysis that related to the flow of the fluids around the swimmer's body (Andersen, Sanders, 2011).

All the mentioned observation methods especially the scientific and less the direct, use the quantitate evaluation, which requires equipment that is not easy to implement by the coaches in a daily training practice. On the other hand, free observation method, which is used in qualitative evaluation shows a great amount of subjectivity (Less, 2002). However, there are some principles which are derived from the science of the Biomechanics that could give a semi-objective character to the technique assessment.

In several studies, the swimming technique in all swimming strokes is evaluated using a video camera, calculations of the kinematic characteristics and lists which include technique mistakes according to the swimmers' level (Costill et al., 1987; Silva et al., 2007; Ceseracciu et al., 2011; Marouco et al.,2010; Madureira et al., 2012; Suito et al., 2017). Moreover, these studies correlate the qualitative evaluation with measurements of anthropometric and performance parameters, such as arms' and legs' length, the strength, and the level of swimmers' flexibility (Silva et al., 2007; Marouco et al., 2010; Madureira et al., 2012; Strzala et al., 2012, 2013).

Thus, the purpose of the current study was to test the validity and reliability of a new and scientific tool, which was developed for the assessment of the swimmers' technique in all four swimming strokes (butterfly, backstroke, breaststroke, and front crawl), and does not require any expensive equipment or quantitative parameters.

It has been hypothesized that this tool will be characterized by high strength of association, strengthening the free observation method that swimming coaches use in practices (Pion et al., 1988). Also, another target is to enhance the quantitative evaluation, reliability, validity and objectivity, decreasing the subjectivity that the free observation method shows (Table1).

Table 1. The types of observation that coaches use in practices and the impact of variables that identify the quality of them

Methods	Free observation			Direct observation			Scientific observation		
Impact	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Variables		Qualitative				Qualitative		Qualitative	
	Quantitative				Quantitative				Quantitative
	Reliability				Reliability				Reliability
	Validity				Validity				Validity
			Subjectivity		Subjectivity		Subjectivity		
	Objectivity				Objectivity				Objectivity

Methods

Sample Characteristics

The sample of the study were 119 Greek swimmers (63 boys and 56 girls) from several swimming clubs in Thessaloniki, aged 8 to 12 years old, with training experience of about 5.4 ±1.7 years. They participate in 6–10 swimming races per year and they train 4–6 times per week. The experimental protocol was approved by the Institutional Review Board and because the participants were underage a signed parental permission was obtained after they were informed about the possible risks and benefits of the current research.

Tec Pa cards

The swimmers' technique was evaluated with Tec Pa (Technique Papadimitriou) cards, which assess six important key points of swimming technique in each stroke. These key points were determined according to surveys, which highlight them as the most important points for correct and fast swimming (Maglischo, 2003; Silva et al., 2007). In general, there are many key points for evaluating the correct technique for each swimming stroke. However, to make this tool easy to use for the assessment of the young swimmers' technique only a small number of key points was selected. Two key points were concerned with each of the following items: the position of the head, the position of the body, the elbows, the knees, the ankles, and the full body coordination.

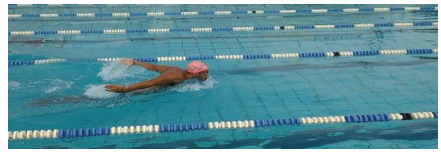
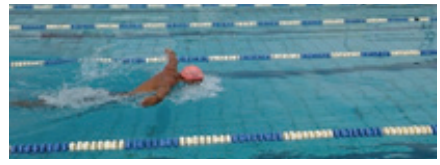
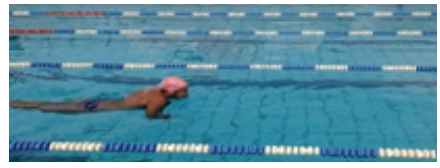
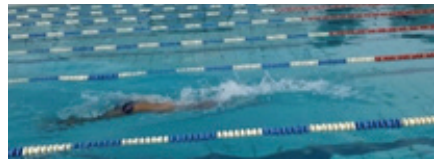
Procedure

Swimmers performed 15m for each one of the swimming strokes (butterfly, backstroke, breaststroke, and front crawl), with the instruction to swim at low intensity and with proper technique. The swimming bouts were recorded by a digital camera (Marouco et al., 2010) placed 5m above the pool's surface. The measurements were conducted in Thessaloniki's national swimming pool during summer period.

The recorded videos were given to and evaluated by three experienced swimming coaches (Madureira et al., 2012), using Tec Pa tool (Tables 2, 3, 4, 5). Each one of the coaches had at least 8 years of experience as trainer with swimmers of these ages (8–12 years). The coaches had a 3-months period to complete the 119 swimmers' evaluation and had to decide with a YES or NO if the swimmers' technique in the six key points of the four swimming strokes was similar to the ideal image and description that Tec Pa shows. This evaluation method, using YES or NO, is in accordance with Ludmina and Janine (2009).

The final score for each swimmer was computed from the sum of the four swimming styles together because it is necessary for the young swimmers to improve all the styles without any specialization in one or two of them. Thus, with this method, if a swimmer had a high score in breaststroke and low in the other styles the sum score will identify a low to moderate general technique level.

Table 2. Tec Pa card for the butterfly

	Butterfly	Correct images	Answer	
Head position	Low breath		Yes	No
	Head's dawning in water entrance		Yes	No
Body position	Body elevation during pulling		Yes	No
	Body sinking during hands extend		Yes	No

Continuation of Table 2

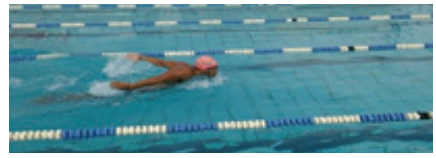
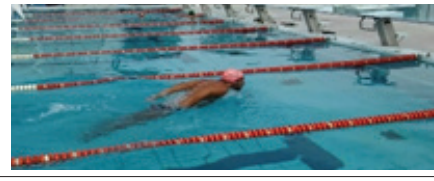
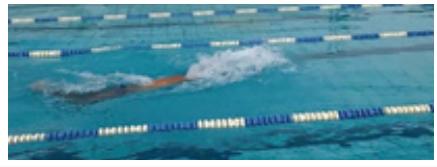
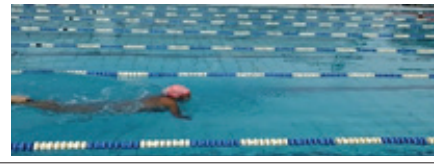
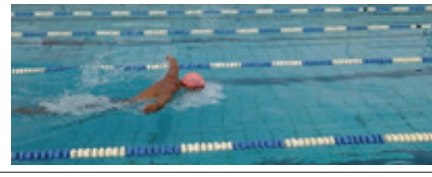
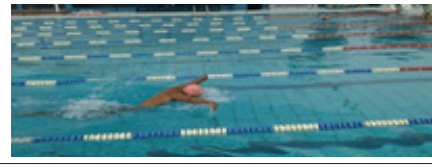
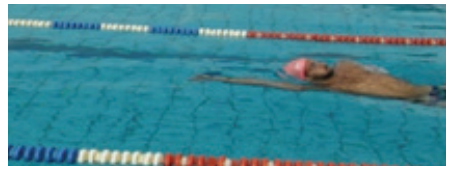
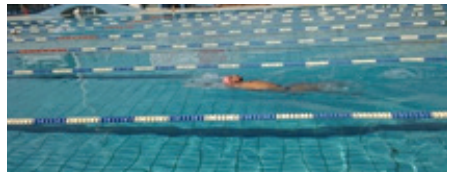
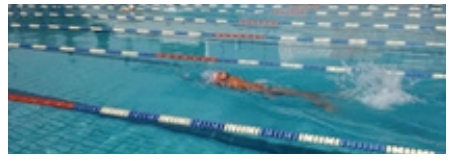
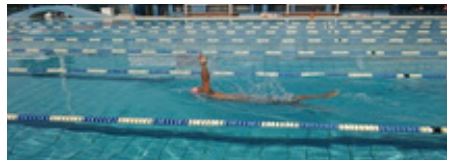
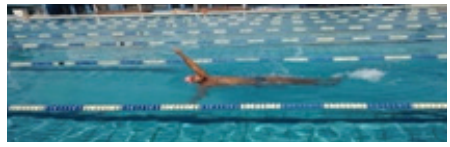
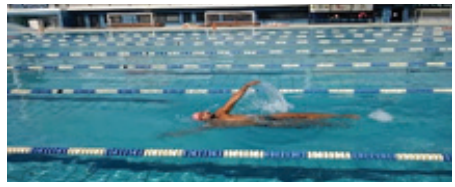
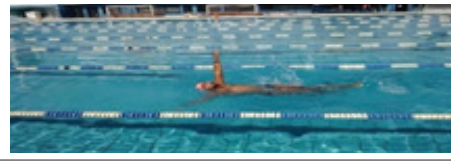
Elbow	High elbows catch		Yes	No
	Elbows' stretch at the begin of the recovery		Yes	No
Knees	Slight knees' flexion during kicking		Yes	No
	Knees' stretching at the end of kicking		Yes	No
Ankle joint	Plantar flexion at the start of kicking		Yes	No
	Heels just break the surface of the water		Yes	No
Coordination	Symmetric hands' movement		Yes	No
	Head's before hands' entrance		Yes	No

Table 3. Tec Pa card for the backstroke

	Backstroke	Correct images	Answer	
Head position	Still head		Yes	No
	Relaxed head position		Yes	No
Body position	Chest on water's surface		Yes	No
	Body rotation		Yes	No
Elbow	Stretch elbow during recovery		Yes	No
	Elbows' direction at the bottom during catch and push		Yes	No
Knees	Slight knee flexion during kicking start		Yes	No
	Knee stretching at the end of kicking		Yes	No

Continuation of Table 3

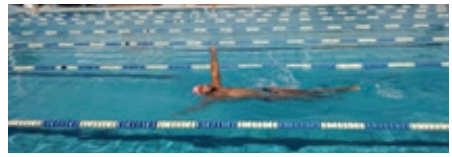
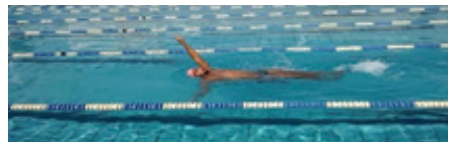
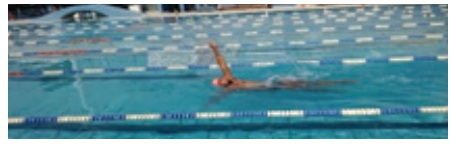
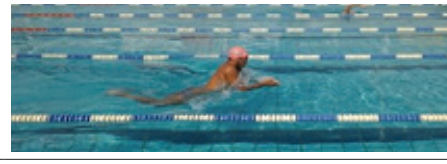
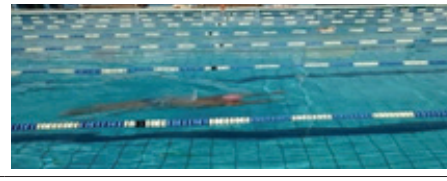
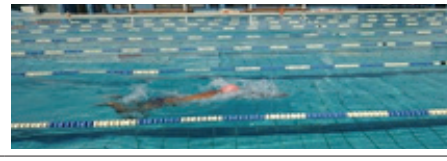
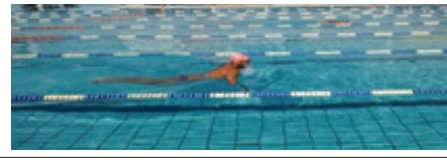
Ankle joint	Plantar flexion during kicking		Yes	No
	Toes just break the surface of the water		Yes	No
Coordination	Hands' opposite position		Yes	No
	Leg kick at each arm cycle		Yes	No

Table 4. Tec Pa card for the breastroke

	Breaststroke	Correct images	Answer	
Head position	Low head position during breathing		Yes	No
	Head between hands during recovery		Yes	No
Body position	Body sinking during recovery		Yes	No
	Body elevation during pulling		Yes	No

Continuation of Table 4

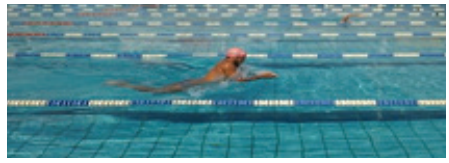
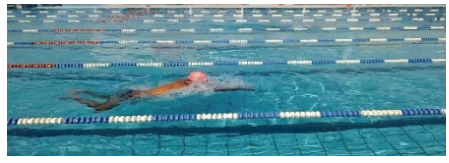
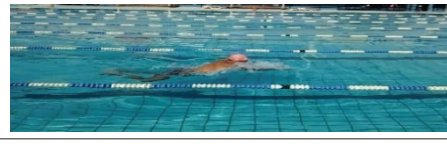
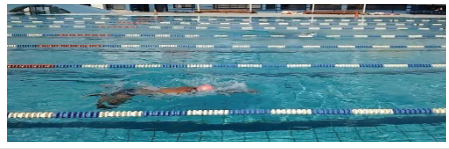
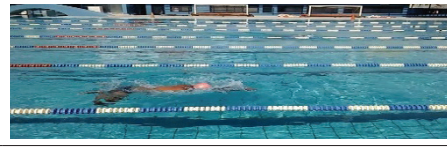
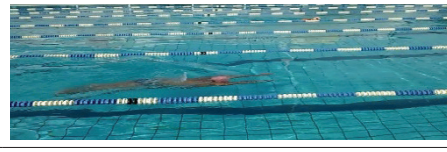
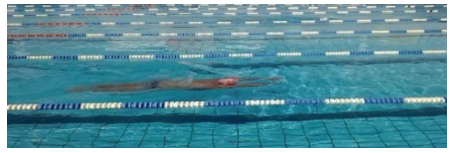
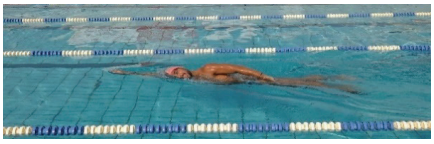
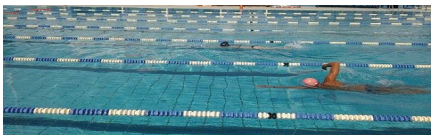
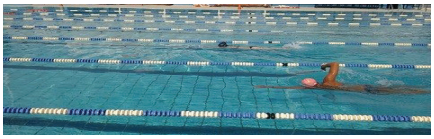
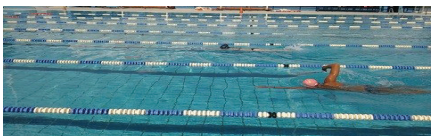
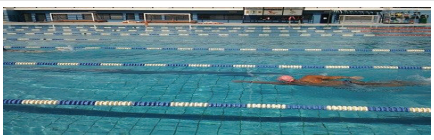
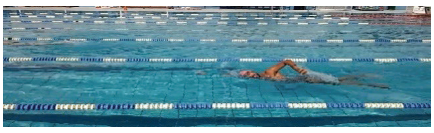
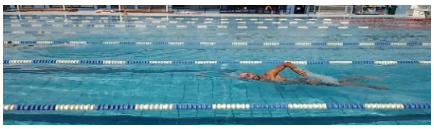
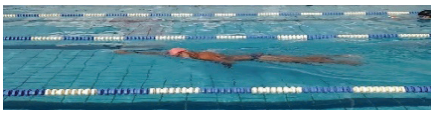
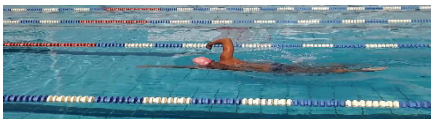
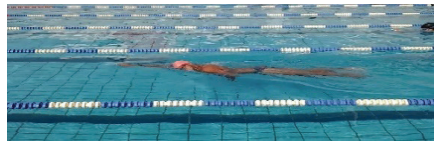
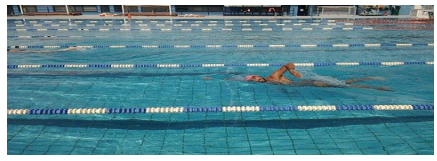
Elbow	High elbows catch		Yes	No
	Elbows squeeze near the body at the end of pulling		Yes	No
Knees	Knees at shoulders' width		Yes	No
	Obtuse angle between body and legs		Yes	No
Ankle joint	Heels swiping near the booty		Yes	No
	Knees external rotation at the kicking start		Yes	No
Coordination	Head downing during hands' recovery		Yes	No
	Hand's stretching at the end of kicking		Yes	No

Table 5. Tec Pa card for the freestyle

	Freestyle	Correct images	Answer	
Head position	Low breathing		Yes	No
	Low head position		Yes	No
Body position	Horizontal body position		Yes	No
	Body rotation		Yes	No
Elbow	High elbow		Yes	No
	Elbow stretch at the end of pulling		Yes	No
Knees	Lower knee's than hip's position		Yes	No
	Slight knees' flexion during kicking		Yes	No
Ankle joint	Plantar flexion during kicking		Yes	No
	Heels just break the surface of the water		Yes	No

Continuation of Table 5

Coordination	Alternately and opposite hand's and leg's movement		Yes	No
	Head's steady side position during breathing		Yes	No

Reliability and Validity

The technique's evaluation tool (Tec Pa) was examined for its reliability and validity. The reliability was examined via the use of the tool by three experienced coaches (Arellano et al., 2002; Madureira et al., 2012). Furthermore, for the validity's confirmation were used the face and content validity methods. In face validity two national-level swimming coaches participated and examined if the tool's sentences can cover the most important technical factors and points in young swimmers. Then, for the content validity, the same national-level swimming coaches plus an academic Professor in swimming examined the precision of the sentences which utilized in Tec Pa tool (Ouzouni, Nakakis, 2011).

Statistical analysis

The score values from the Tec Pa tool are showed as median with standard deviation (±). Descriptive statistic and test of normality (Kolmogorov-Smirnov) for the swimmers' scores were used ($p > 0.05$). Furthermore, for the possible differences, and the strength of association between the three swim coaches' evaluation, one-way ANOVA with repeated measures, Bonferoni test and Kendall's τ correlation coefficient were used respectively. The analysis was performed using the SPSS Version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $\alpha = 0.05$.

Results

The scores showed normality ($p > 0.05$), so parametric analysis was utilized. We did not observe any statistically significant difference ($p > 0.05$) between the swimming technique scores that swimmers were evaluated by coaches (Figure 1).

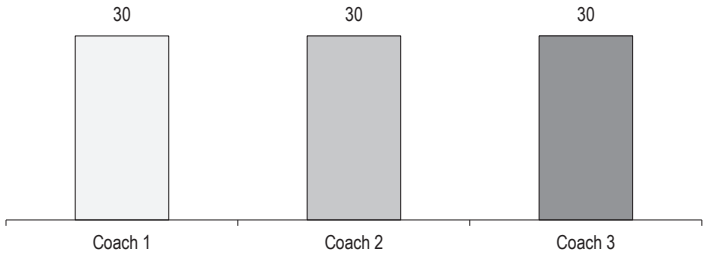


Figure 1. The coaches' evaluation in the four swimming strokes using the Tec Pa application

Coaches (1–2): 29.9 ±6 – 29.7 ±7 (p = 0.90). Coaches (2–3): 29.7 ±7 – 30.4 ±6 (p = 0.19) and Coaches (1–3): 29.9 ±6 – 30.4 ±6 (p = 0.46).

The results revealed a significant positive association between the evaluations of the three coaches. The value of Kendall's τ correlation coefficient was statistically significantly high ($\tau = 0.863$; $p < 0.05$).

Discussion

According to the findings of the current study showed that the tool for the evaluation of swimmers' technique (Tec Pa) is a user friendly, reliable, and valid, with high association strength for the free observation method (Pion et al., 1988). Swimmers' technique can be directly, easily, reliably, and validly assessed when they swim. In the literature, the free observation method seems to show a low impact in quantitative evaluation, reliability, validity, and objectivity while it shows a moderate impact on the qualitative evaluation, and high subjectivity. However, it is a method that is used by all swimming coaches, especially for young swimmers because in these ages the free observation method is the most direct, economical, and fast (Pion et al., 1988).

According to the study results, the impact of that method was enhanced. Firstly, the impact of reliability through the association of the evaluation scores by the three swimming coaches was increased. Also, the suggestions of the two national-level swimming coaches plus the academic Professor in swimming confirmed the tool's face and content validity (Ouzouni, Nakakis, 2011).

Moreover, the strength of association between the scores from the three swimming coaches, decreased the subjectivity and increased the objectivity. Also, the tool's specific qualitative technique key points that were highlighted through the images contributed to the enhancement of the free observation method. Thus, the statement of Mooney et al. (2015) about the difficulty of use of the qualitative observation method seems to be confuted by this tool.

Similar swimming technique assessment methods were also shown by Silva et al. (2007), Marouco et al. (2010), Madureira et al. (2012) and unpublished data. According to Silva's et al. (2007) study the tool's usage enhances more the direct observation method. However, they did not use any images to demonstrate the technique's key points, they only highlighted the technical mistakes and not technique's correct execution and they used fewer technique spots for assessment.

On the contrary, the study's current tool enhances the free observation method. Images were used to demonstrate technique's each key point, helping the coaches to understand better what they had to assess in

the technique of each swimmer. Also, in tool more body key points (head, body, elbows, knees, ankles, and body coordination) were used for the better swimmers' evaluation by the coaches. Thus, the way that the tool was constructed contributed to the high association between the coaches' evaluation. Moreover, these cards can be used by the swimmers as a game, helping them to learn the correct swimming technique, and having fun at the same time.

Marouco et al. (2010) and Madureira et al. (2012) used the qualitative evaluation through the free observation method. In these studies, the swimmers' evaluation occurred by listing the technique faults that swimmers made. Specifically, in Marouco et al. (2010) study, the older the swimmer was, the more detailed the technique's assessment was. While, in Madureira et al. (2012) study the fault list contained a value between zero (no technique mistakes) and 152 points for detailed and precise evaluation. However, in these studies, the qualitative parameters were related to quantitative parameters such as stroke rate, stroke length, etc. to enhance their evaluation method effectiveness.

In unpublished data there is a tool that can assess swimmer's technique through technique evaluation cards. However, the questions do not meet any scientific principles of validity and reliability that Tec Pa cards show. Also, as described previously, the pictures of correct swimming highlight the most important technique's spots. Thus, coaches can easily evaluate swimmers' technique.

In the study, the evaluation was performed using only qualitative criteria because the point was to enhance qualitative technique analysis without the contribution of quantitative parameters. On the other hand, the more detailed analysis that Marouco and Madureira performed enhance the precision of technique's analysis. Nevertheless, the specific Tec Pa's use in young swimmers highlights the most important technique elements that are productively for that ages. However, a future tool's improvement could increase the body's technique key points for a more detailed technique analysis

In young swimmers, generally, it is important to find the mistakes and then classify them according to their importance. Technique's classification according to its importance and the more detailed analysis that Silva's et al. (2007) Marouco et al. (2010) and Madureira et al. (2012) used respectively are the parts that will improve Tec Pa. Thus, this would be a future perspective for a possible Tec Pa's to be upgraded for a more detailed technical evaluation in older swimmers with longer training experience and a higher level of technique.

Conclusion

The study showed that the technique evaluation tool (Tec Pa) is something fresh and upgraded in swimming coaching and could be used by the swimming coaches to enhance the free observation method that is always used in children. Also, the tool can evaluate reliably and validly young swimmers' technique in a general way, which is the most important issue on several performance occasions.

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